Low Mass Vector Meson Production in pp collisions at forward rapidity at $\sqrt{s}$ = 200 and 510 GeV at RHIC

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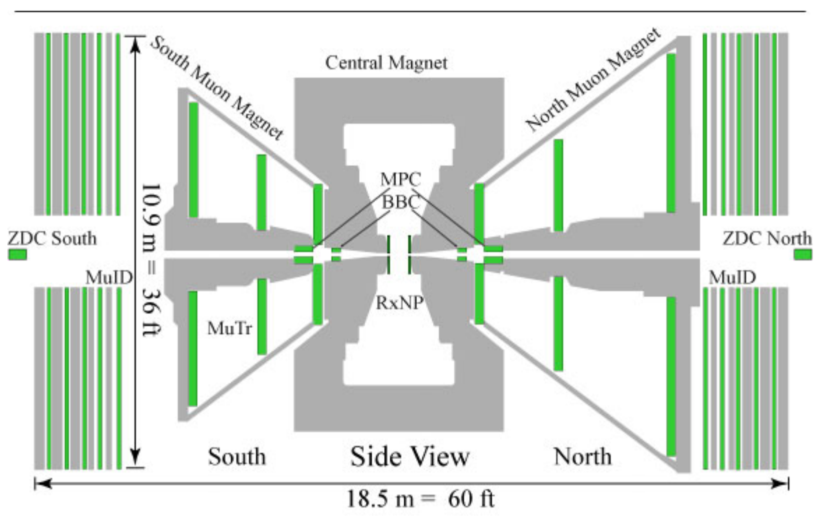
Introduction

Low mass vector meson (ρ,ω,ϕ) production in pp collisions is an important tool to study QCD, providing data to tune phenomenological QCD models.

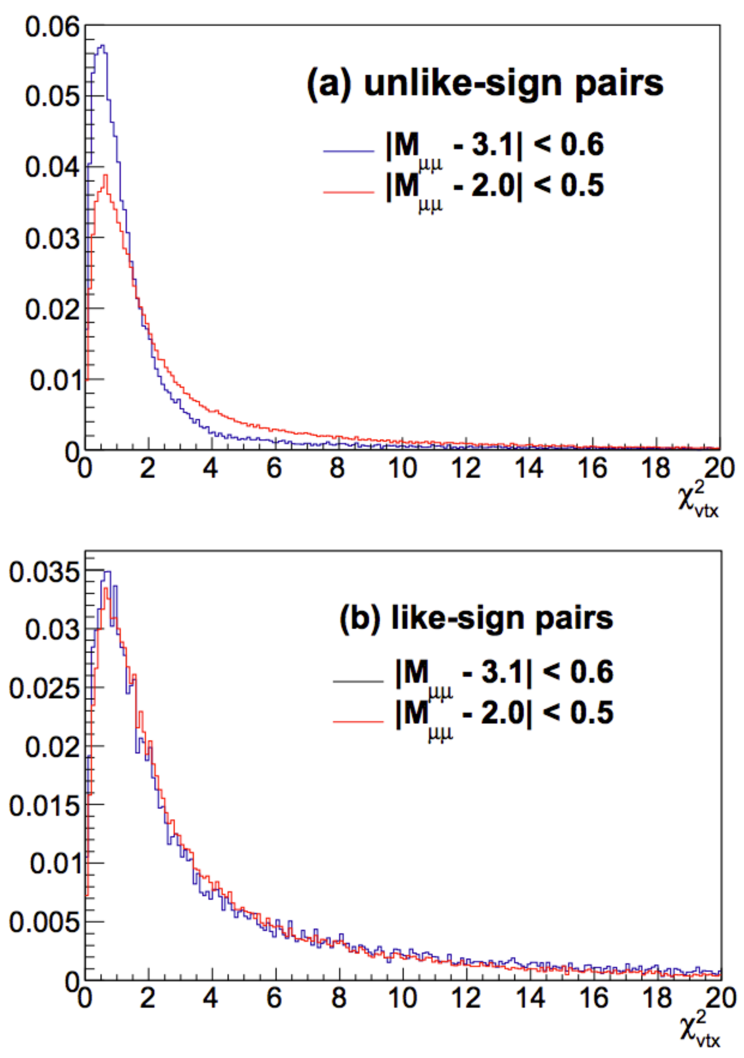
Low mass vector meson studies provide key information on the hot and dense state of the strongly interacting matter produced in Heavy Ion collisions. Measurements in pp collisions provides reference for these studies.



Strangeness enhancement, a phenomenon associated with soft particles in bulk matter, can be accessed through the measurements of ϕ meson production and **ϕ/(ω+ρ) ratio**.

PHENIX experiment at RHIC is able to study vector meson production via their dimuon decay channel using its two muon spectrometers covering the rapidity range 1.2 < |y| < 2.2

Signal Extraction



Dimuon invariant mass distribution is formed by combining muon candidate tracks of opposite charge. Therefore, this spectra contains correlated muon pairs as well as uncorrelated background. Traditionally, uncorrelated background is subtracted using the invariant mass spectra of the like-sign pairs or using the so called "event-mixing" technique. The dimuon correlated spectra is then described by all known sources (2 body and Dalitz decays of low mass mesons, quarkonia dimuon decays and open-charm and open-beauty semi-muonic decays).

We developed here a new method to evaluate the non-resonant sources to the dimuon spectra using the χ^2 of a simultaneous fit of the two muon tracks with a common vertex along the beam axis given by the Beam-Beam Counter (BBC). Fig. 1 shows how different the χ^2_{vtx} distribution shapes are between resonant and non-resonant regions.

***Fig. 1**: The χ^2_{vtx} distributions for non-resonant mass region (red), and signal (J/ψ) mass region (blue) for unlike-sign (a) like-sign (b) pairs. In each panel, the histograms are normalized to the total number of events.*

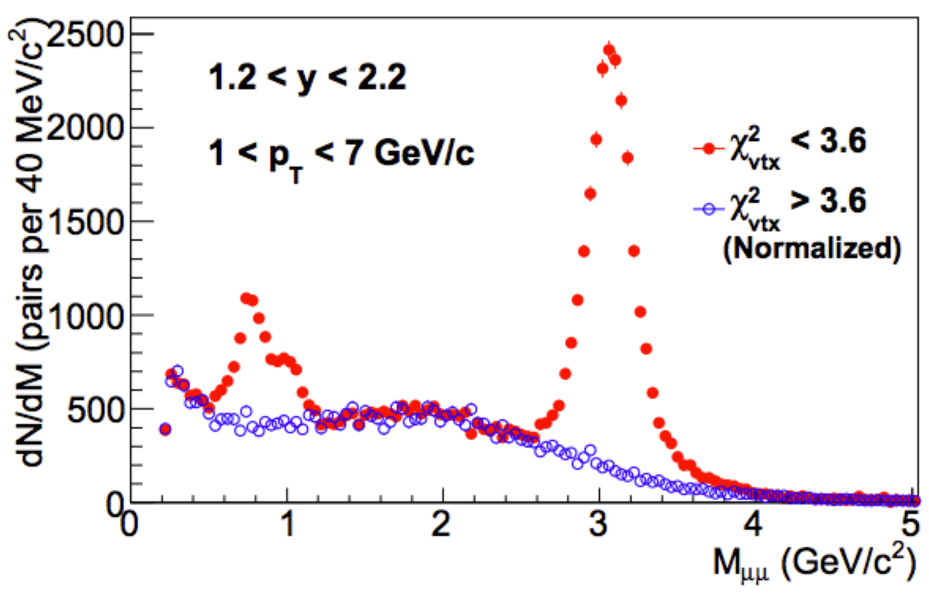


***Fig. 2**: The unlike-sign dimuon invariant mass spectrum (solid red circles) and the background spectrum (empty blue circles).*

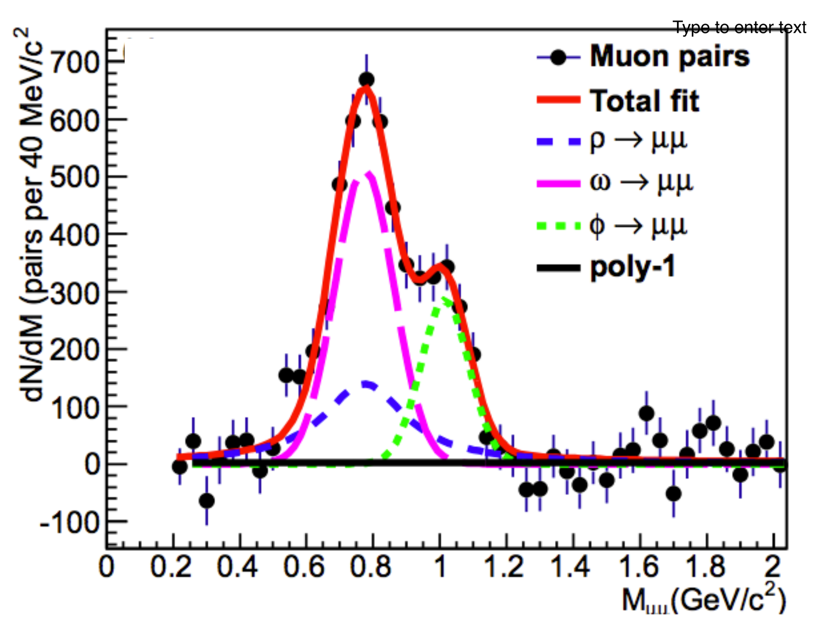


***Fig. 3**: Fit of the mass spectrum resulting of the background subtraction.*

Shape of the correlated plus uncorrelated background to the unlike-sign dimuon spectra is determine applying a cut such that χ^2_{vtx} > 3.6. Normalization is given by the same analysis of the like-sign spectra (see Fig. 2).

The resulting dimuon mass spectrum (Fig. 3) is fitted in the low mass region ($M_{\mu\mu}$ < 2 GeV/c^2) by the superposition of two Gaussians (ω and ϕ), a Breit-Wigner (ρ) and a first order polynomial (any remaining background). Contribution of ρ is fixed to the one of ω such that $\sigma_\rho/\sigma_\omega$ = 1.15.

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Results at 200 GeV

Production cross sections of ω+ρ and ϕ have been extracted as a function of transverse momentum (1 < p_T < 7 GeV/*c*) and rapidity (1.2 < |y| < 2.2), see Fig. 4.
Results are compared to different PYTHIA tunes and PHOJET simulations. ATLAS-CSC and PHENIX tunes of PYTHIA reproduce reasonably well the data for both ω+ρ and ϕ cross sections. Where the other simulations under-predict the ϕ cross section by a factor 2.

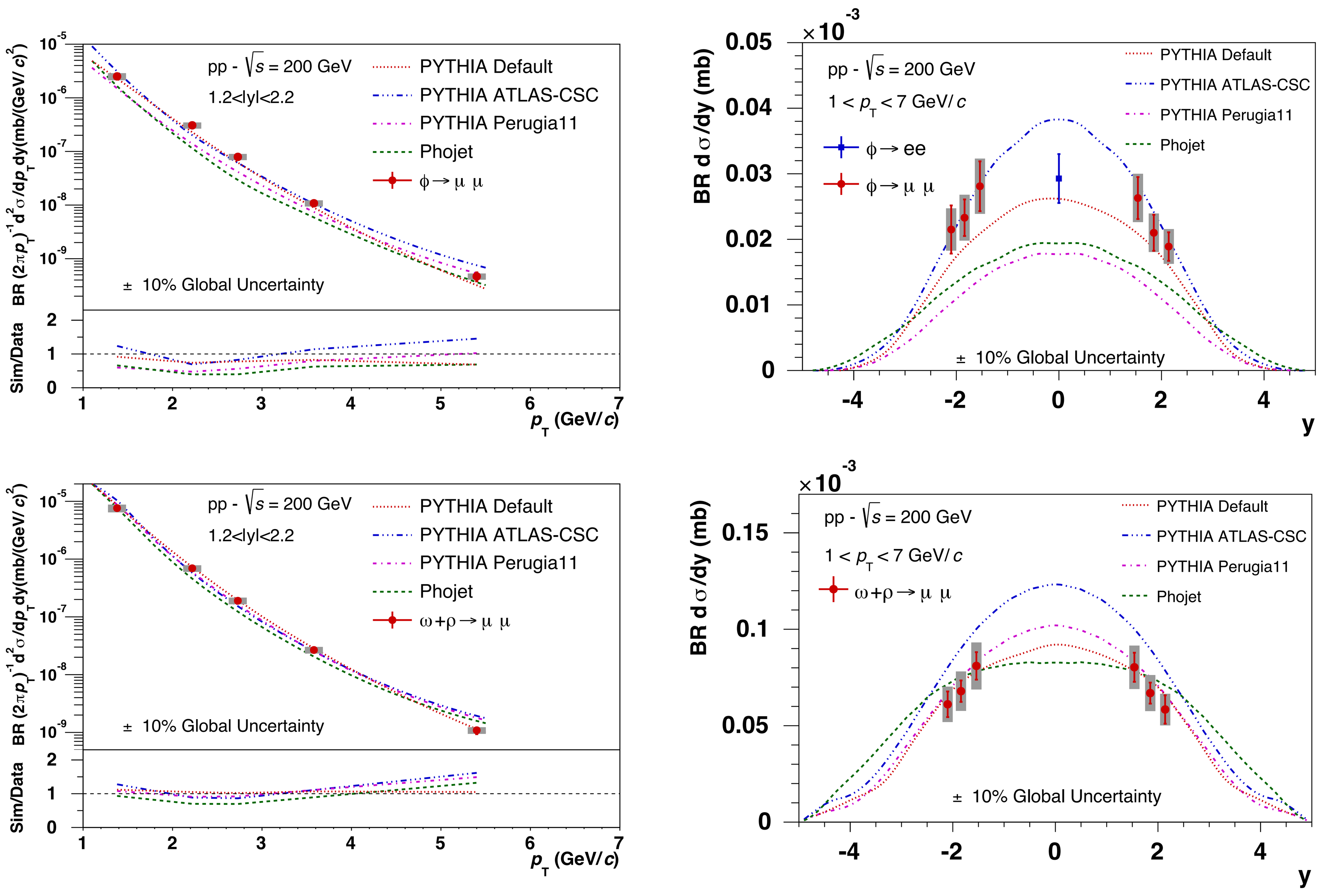

***Fig. 4**: p_T dependent differential cross sections (left panels) and rapidity depend differential cross sections (right panels) of ϕ (top panels) and ω+ϕ (bottom panels). The error bars represent the quadratic sum of the statistical uncertainties and uncorrelated systematic uncertainties, and the gray shaded band represents the quadratic sum of correlated systematic uncertainties.*

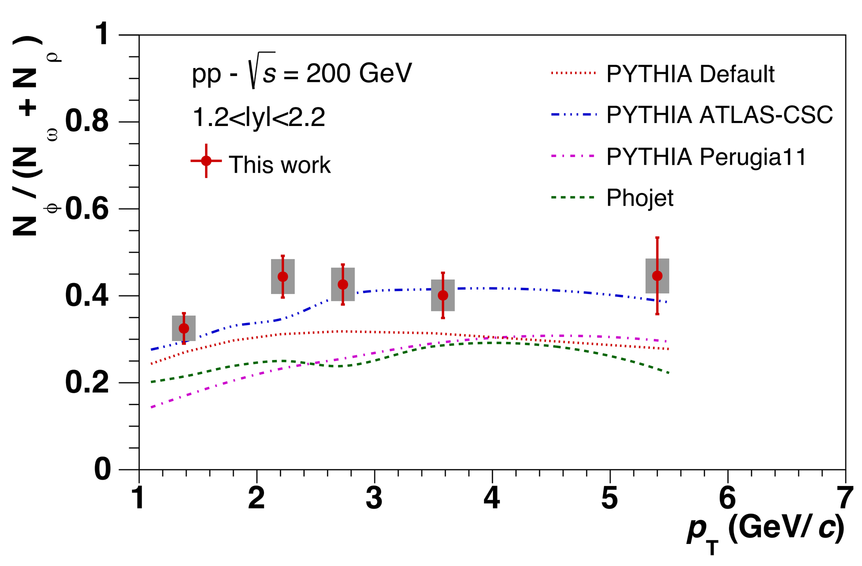

***Fig. 5**: Yield ratio $N_\phi/(N_\omega+N_\rho)$ as a function of p_T.*

Yield ratio $N_\phi/(N_\omega+N_\rho)$ have been measured as a function of p_T (Fig.5) showing a moderate increase versus p_T, compatible with ATLAS-CSC PYTHIA tune simulation where other simulation results under-predict this ratio.
The average value of $N_\phi/(N_\omega+N_\rho)$ over the p_T (1 < p_T < 7 GeV/*c*) and rapidity (1.2 < |y| < 2.2) range was determined to 0.390 ± 0.021 (stat.) ± 0.016 (syst.). This result is compatible with the ALICE experiment result of 0.416 ± 0.032 (stat.) ± 0.004 (syst.) [1] measured in pp collisions at 7 TeV for 1 < p_T < 5 GeV/*c* and 2.5 < y < 4.

On going analysis at 510 GeV using FVTX

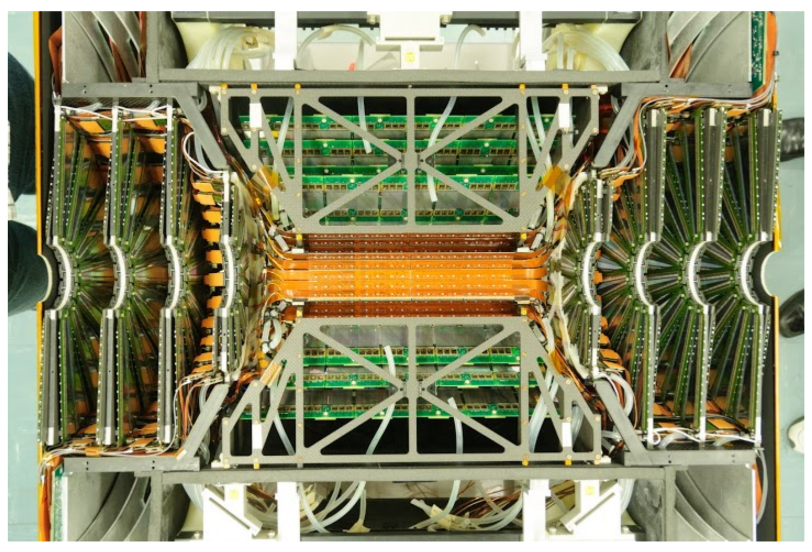

***Fig. 6**: Picture of the PHENIX inner tracker formed of the VTX (mid-rapidity) and of the FVTX (forward/backward rapidities).*

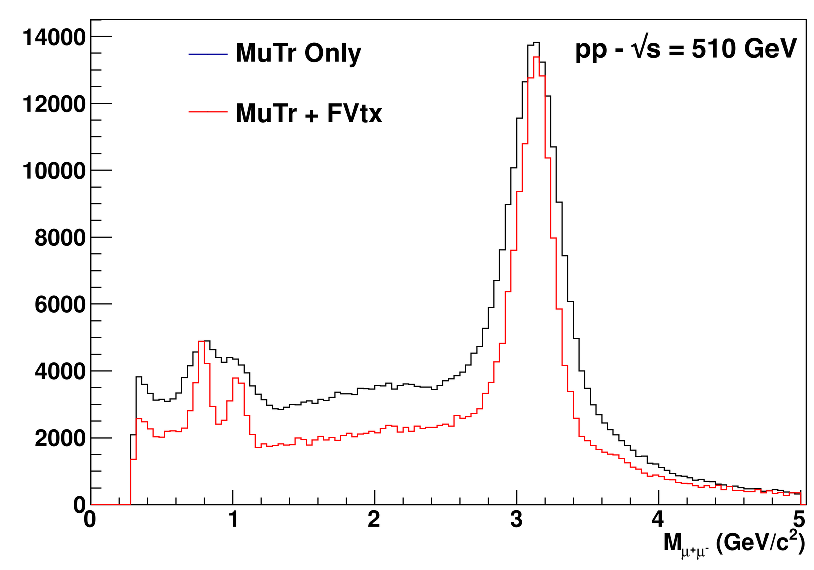

***Fig. 7**: Unlike-sign dimuon invariant mass spectra recorded during run 13 with (red curve) and without (black curve) using the FVTX.*

Since 2012, the PHENIX experiment is equipped with a silicon strip tracker (the FVTX, Fig. 6) in the muon spectrometer acceptances upstream of the hadronic absorber. Muon tracks measured in the spectrometers are extrapolated back to the interaction point and attached with clusters left by the muon in the FVTX. The resulting dimuon mass resolution improve drastically thanks to a better determination of the opening angle between the two muons (Fig.7).
Analysis of run 13 data (pp @ 510 GeV) with and without FVTX is ongoing. The FVTX addition opens new prospective to the low mass vector meson studies in PHENIX. Analysis of the ongoing run 14 data (Au-Au @ 200 GeV) will allow to study the in-medium modification of the low mass vector meson production.

Reference:

[1] B. Abelev et al. (ALICE Collaboration), Phys. Lett. B 710, 557 (2012).